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IRISH CENTRE FOR RESEARCH
IN APPLIED GEOSCIENCES

Australian Earth Sciences Convention (AESC)
Feb. 11, 2021

A World Leading SFI Research Centre

**The Energy Transition:
Implications for Geoscience - a View from the North**

Prof. Murray Hitzman Irish Centre for Research in Applied Geoscience, Ireland

HOST INSTITUTION
UCD DUBLIN University College Dublin
An Coláiste Ollscoile, Baile Átha Cliath

PARTNER INSTITUTIONS
Trinity College Dublin, DIAS, NUI Galway, UCC, Maynooth University, eogasc, DCU, Geological Survey

https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html

FUNDED BY: European Union, SFI

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Photo: Juergen Lang

The Energy Transition: Implications for Geoscience - a View from the North

Three themes:

- What and why
- Impact on research
- Effects for geoscientists

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https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html

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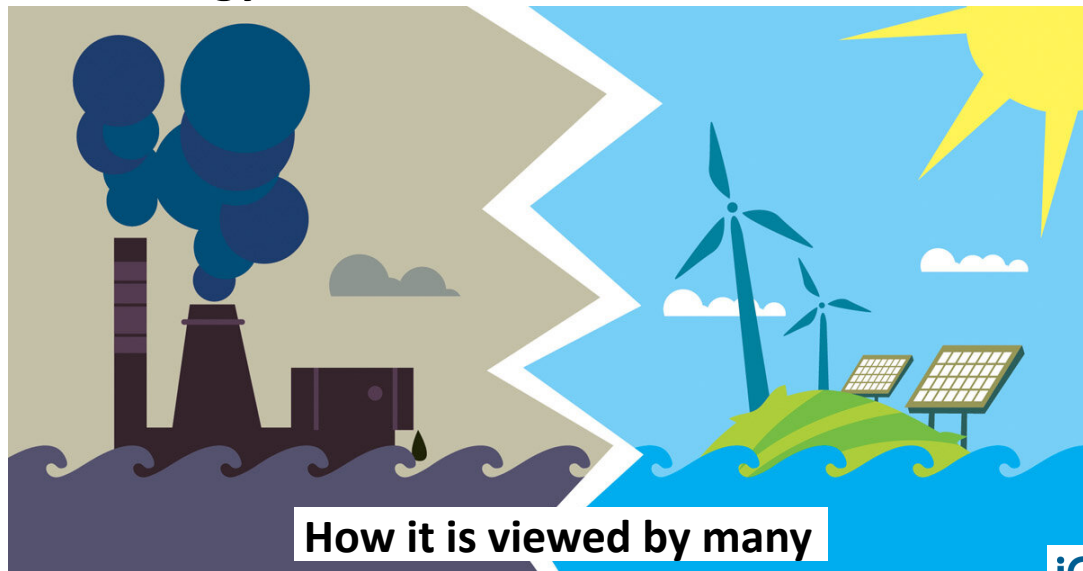
The Energy Transition and Geoscience — Who Am I to Speak?

USGS
science for a changing world

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The Energy Transition

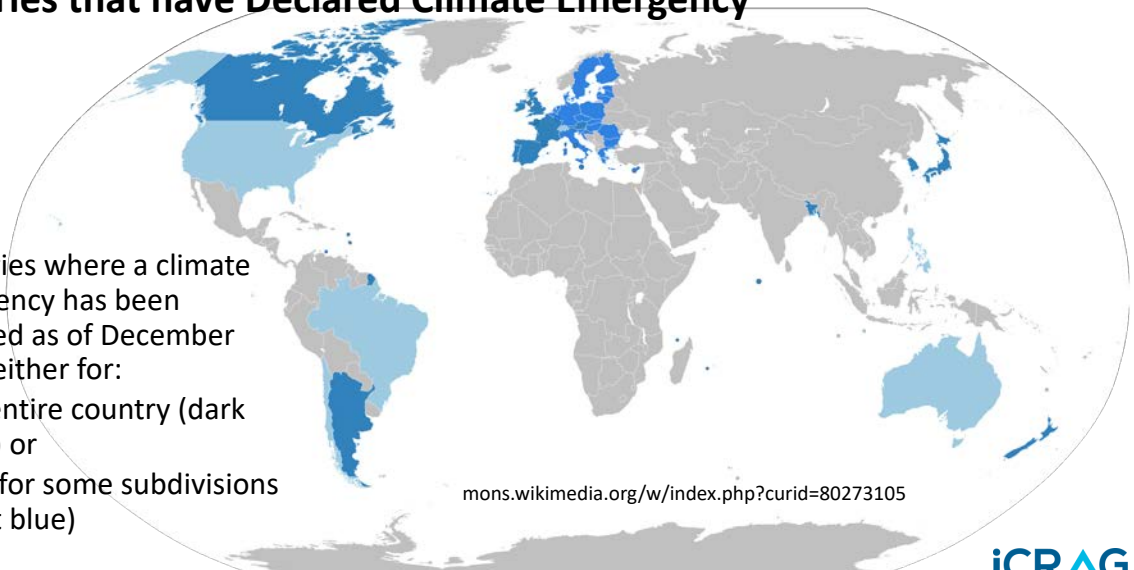


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Why the Energy Transition? Countries that have Declared Climate Emergency

Countries where a climate emergency has been declared as of December 2020, either for:

- the entire country (dark blue) or
- only for some subdivisions (light blue)



mons.wikimedia.org/w/index.php?curid=80273105

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Why the Energy Transition?

Our World
in Data

The size of the world population over the last 12,000 years

Nature, 3 January 2002

Geology of mankind

Paul J. Crutzen

For the past three centuries, the effects of humans on the global environment have escalated. Because of these anthropogenic emissions of carbon dioxide, global climate may depart significantly from natural behaviour for many millennia to

referring to the "anthropozoic era". And in 1926, V. I. Vernadsky acknowledged the increasing impact of mankind: "The direction in which the processes of evolution must proceed, namely towards increasing consciousness and thought, and forms having greater and greater influence on their surroundings." Teilhard de Chardin and

concepts

The Anthropocene

The Anthropocene could be said to have started in the late eighteenth century, when analyses of air trapped in polar ice showed the beginning of growing global concentrations of carbon dioxide and methane.

Anthropocene



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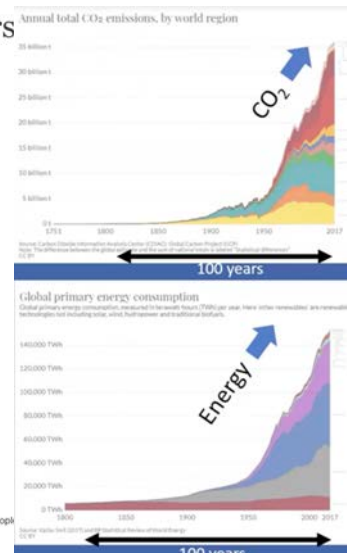
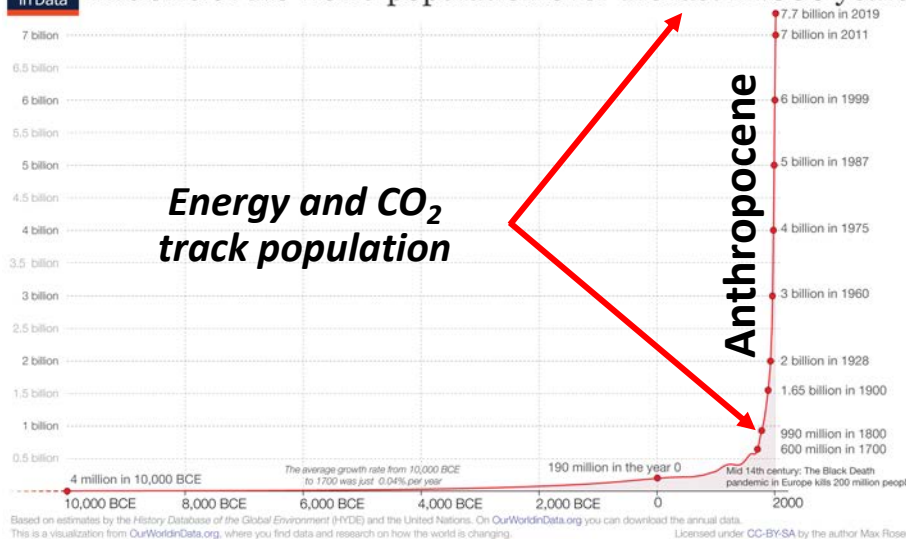
Why the Energy Transition?

Our World
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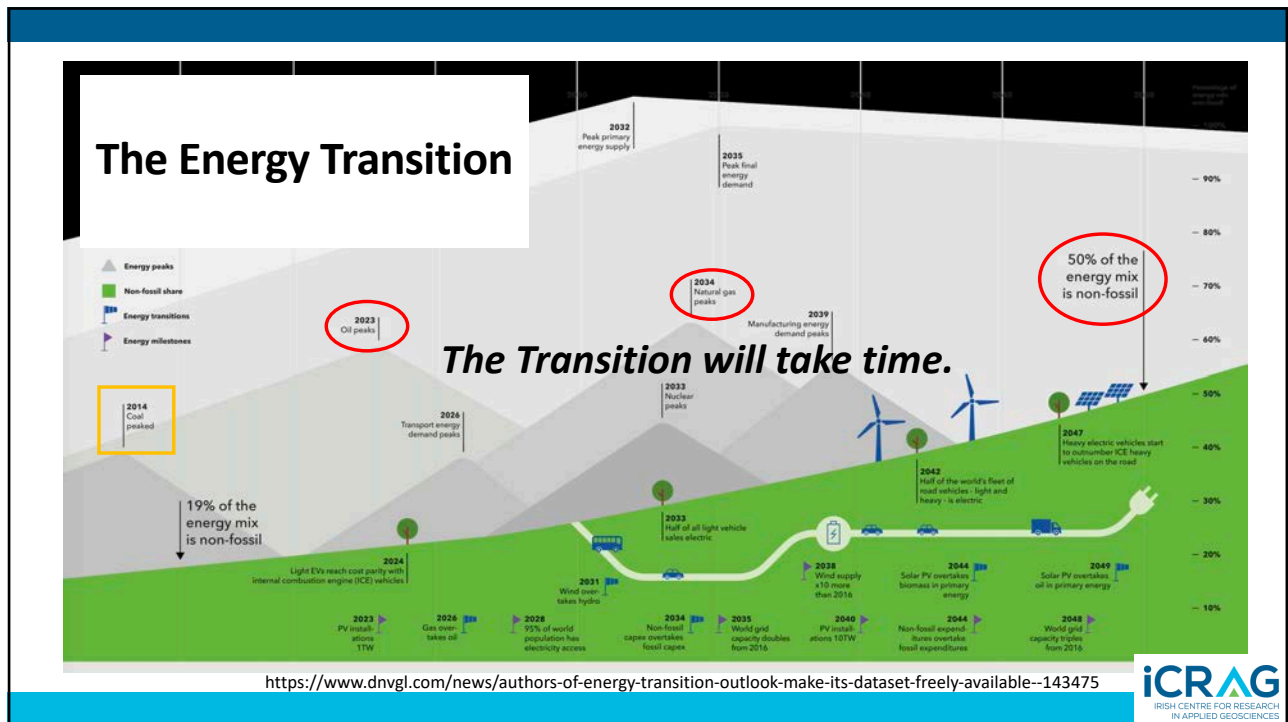
Energy and CO₂
track population

Anthropocene

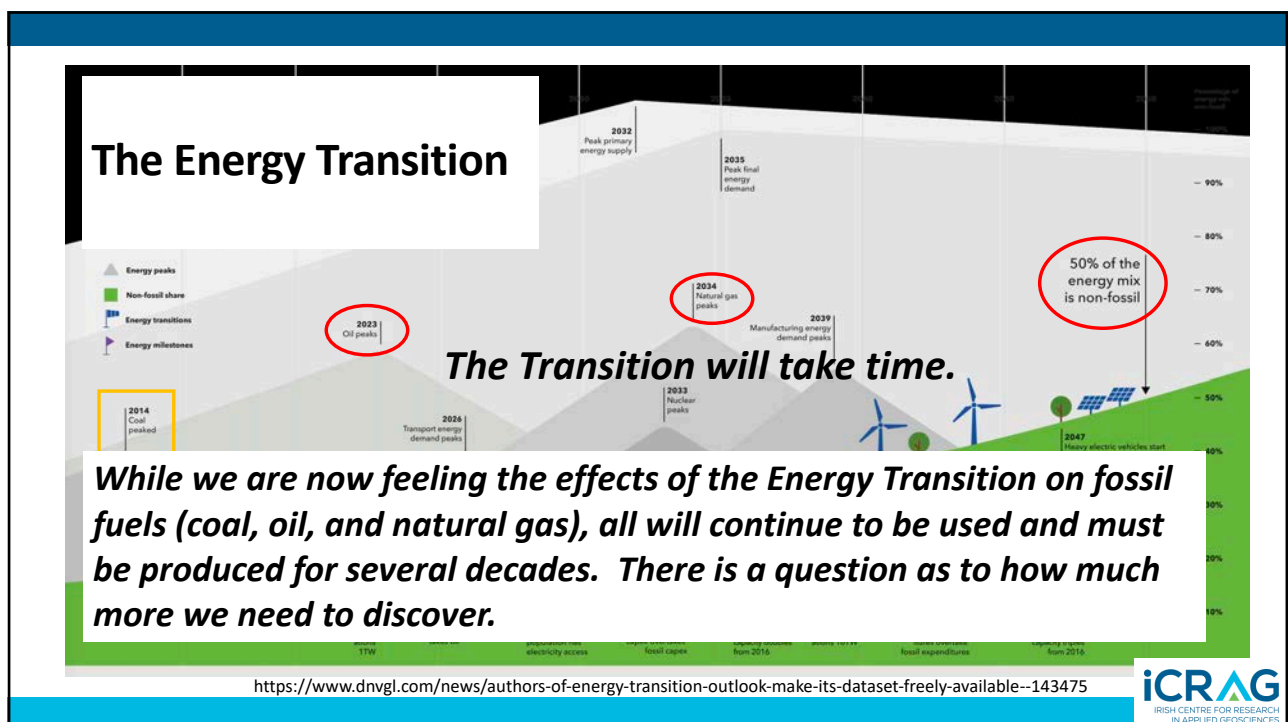


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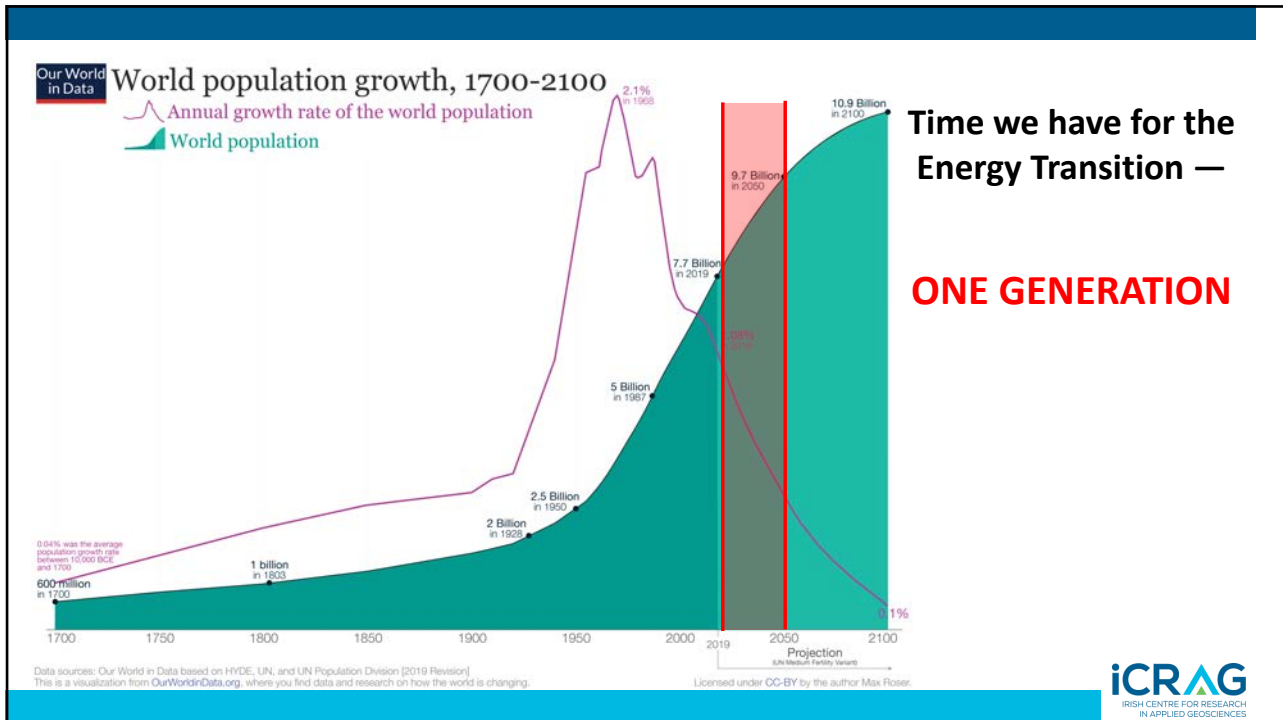
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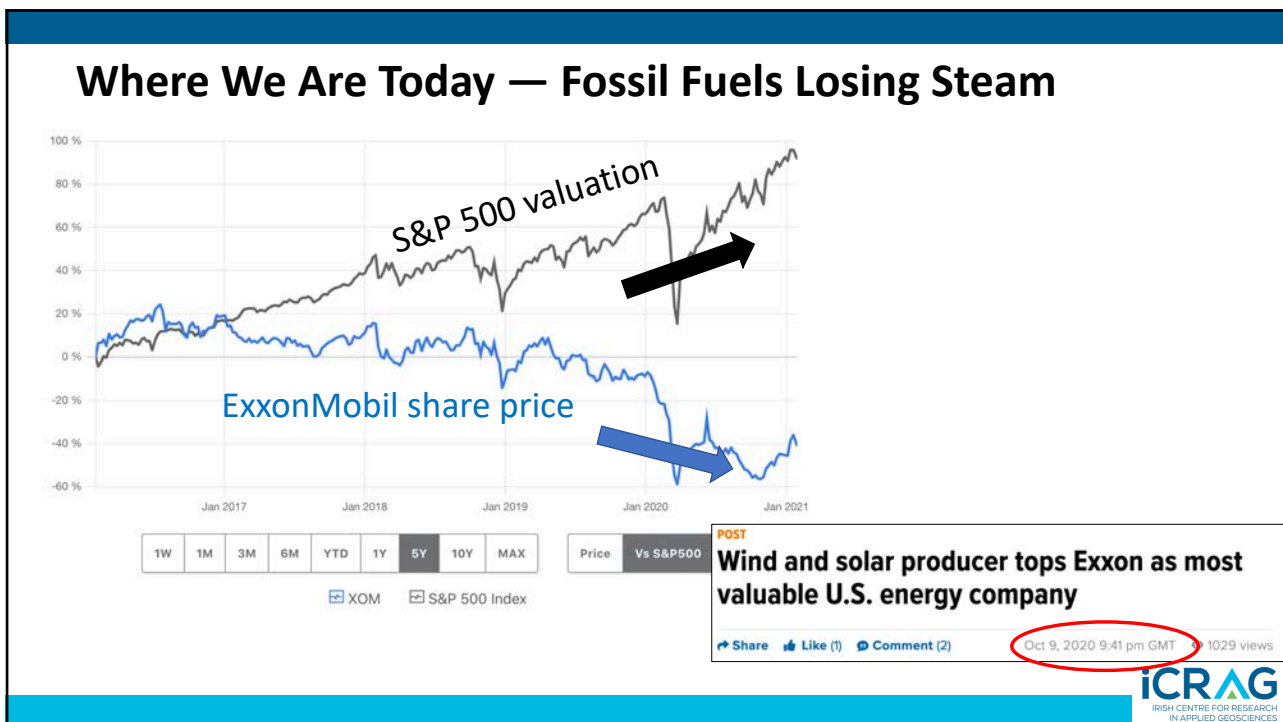
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Where We Are Today — Fossil Fuels Losing Steam

- Getting more pronounced

The Washington Post

Oil companies' losses in 2020 were staggering. And that was before the government focused on climate change

A bad global economy, Biden's climate change priorities and the promise of all-electric vehicles are feeding petroleum pessimism

By **Will Englund**

Feb. 4, 2021 at 1:34 p.m. GMT



Conoco Phillips announced this week that it lost \$2.7 billion in 2020. BP and Chevron each lost just over \$5.5 billion. ExxonMobil posted a loss of \$20 billion.

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Fossil Fuels also Losing Steam in Australia

ASX 300 vs fossil fuel dominated ASX 300 Energy

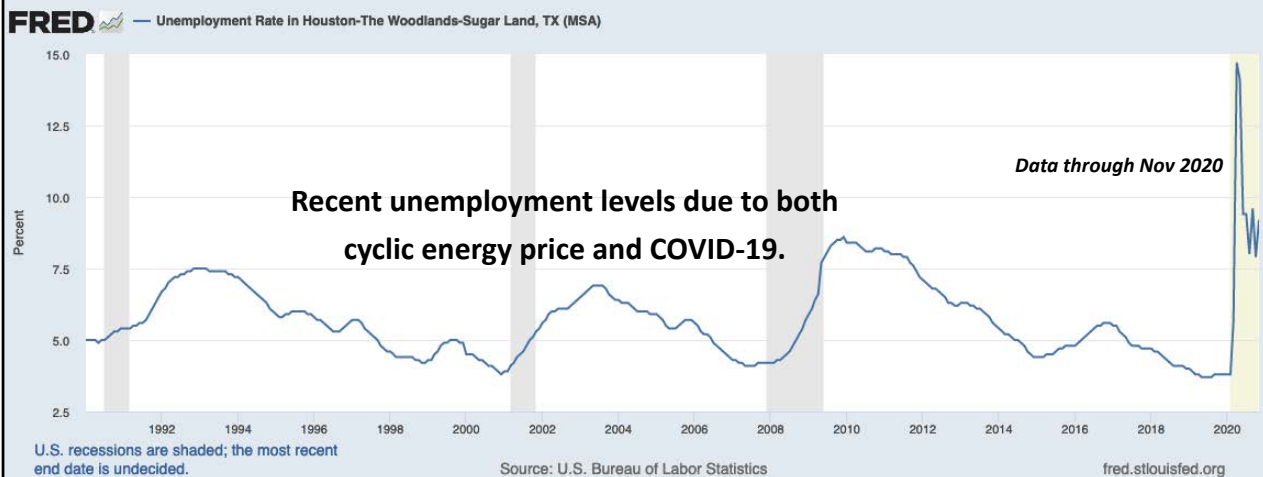


Energy transition appears to have started in 2012.

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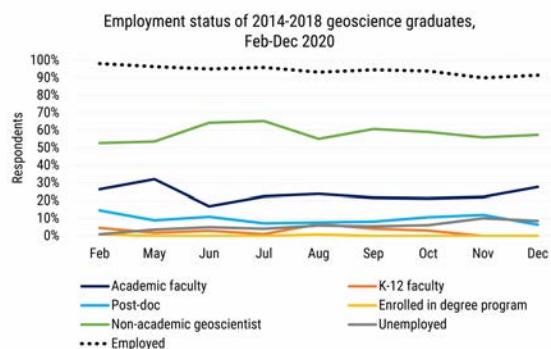
Energy Transition's Human Face — Unemployment in Houston, TX



- US Bureau of Labor Statistics

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The Human Dimension



Credit: AGI; data from AGI's Geoscience COVID-19 Survey

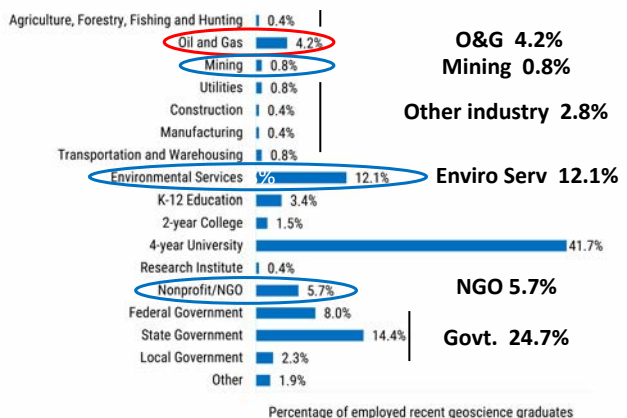
Little evidence of decreased employment in 2020 due to Energy Transition or COVID-19.

Credit: AGI; data from AGI's Geoscience COVID-19 Survey

AGI data, 2021

But a transition from O&G employment?

Industry sectors of employed recent geoscience graduates, December 2020



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COVID-19 and the Energy Transition



The pandemic has spurred new ways of communicating and conferencing that will permanently alter travel habits and work patterns, with the potential to save significant energy.



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The Energy Transition — Research Impact on the iCRAG 1 Research Centre

- Established in 2015 (*I joined as Director 2018*)
- One of 17 State-funded National Research Centres
- Includes researchers from 5 universities and 2 institutions
- Goals of Centre:
 - Help unlock Ireland's natural resources (offshore petroleum; onshore minerals)
 - Contribute to securing supply of energy and safe water
 - Educate and improve understanding of geosciences
 - To achieve international excellence in applied geoscience research.



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iCRAG 1 Research Centre (2018)

Jointly funded by Science Foundation Ireland (€18M) and industry (€8M)

National & EU Funding Bodies



Geoscience State Bodies



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iCRAG 1 Industry Partners (2018)



Over a third were O&G companies.



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iCRAG 1 Research Centre (2018)

- 150 researchers
- 5 research Spokes
- 4 research Platforms to support Spokes

11 Principal Investigators

41 Funded Investigators

45 Post-Doc researchers

45 PhD researchers

8 MSc students

4 Other (RA, IT, Snr. Geo)

9 Operational Staff



The Centre was funded from day 1 by O&G money and hydrocarbons research dominated the agenda.

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The Energy Transition - Impact on the iCRAG Research Centre

- Centre was funded to end 2020.
- In 2019 a proposal was prepared to secure funding for a phase II.
- But the world was changing....



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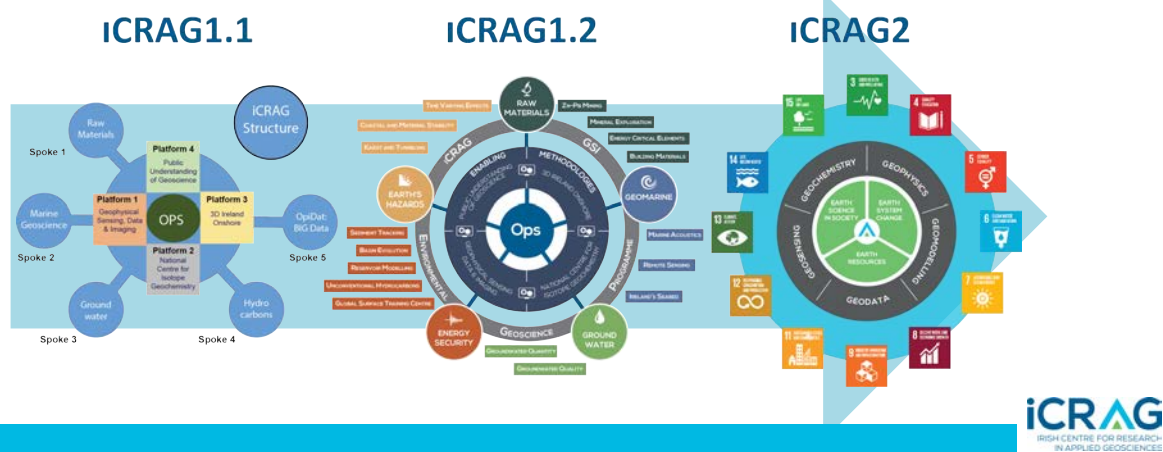
The Energy Transition Impact on the iCrag 1 Research Centre

Description of Energy in iCrag

2018 — petroleum, natural gas, geothermal and wind

2019 (first iCrag2 proposal) — natural gas, wind, geothermal

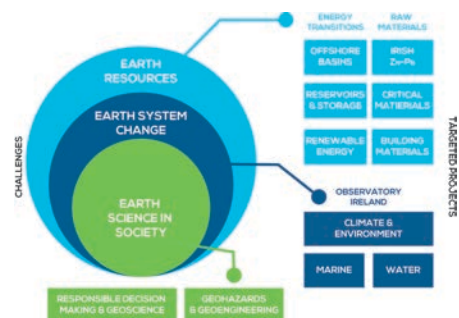
2020 (modified iCrag2 proposal) — wind, geothermal



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The Energy Transition — Impact on the iCrag Research Centre

- iCrag2 is now organized around 3 grand challenges.
- Only renewable energy is highlighted.
- Hydrocarbon expertise is being utilized in:
 - Reservoirs and storage — geothermal and carbon capture and storage (CCS).
 - Climate and environment in defining paleoclimate from offshore geology.
 - Significant inputs into marine and onshore geology research.
- Major focus on raw materials - critical metals (especially battery metals) and construction materials.
- Water remains a major focus.
- New focus on climate and environment.
- New focus on responsible decision making and geoscience (addition of social scientists).



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What Does the iCRAG Journey have to Tell us about the Energy Transition and Geoscience Generally?



An era of significant, cyclically available research funding (and long-term high paying permanent employment) from the O&G industry is coming to an end...

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The Energy Transition

iCRAG focus areas probably mirror those for most geoscience research groups going forward



- Water
- Minerals (Raw Materials)
- Environmental
- Hazards
- **Climate** - particularly past climates and effects in present.

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These are also the Geoscience areas needed in a Climate Emergency



- **Water**
- **Minerals (Raw Materials)**
- **Environmental**
- **Hazards**
- **Climate** - particularly past climates and effects in present.



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Water, water, water



• *Too much*



• *Too little*

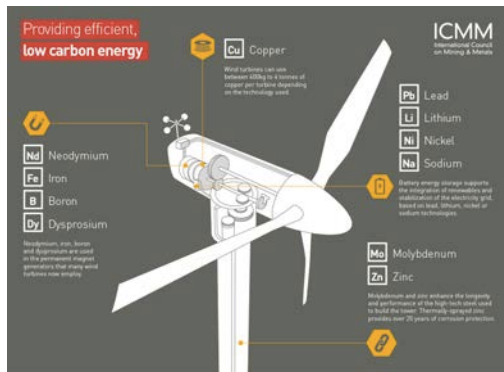


• *Too polluted*

There will be jobs in academia, industry and government in water and a host of research problems that can be funded.

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Raw Materials (Minerals/Metals)



There will be jobs in academia, industry and government dealing with minerals of all kinds, and a host of research problems that can be funded.

Raw Materials Needed for IT Infrastructure

The Cloud



<https://hydrosystemsco.com/taking-technology-to-new-heights/>



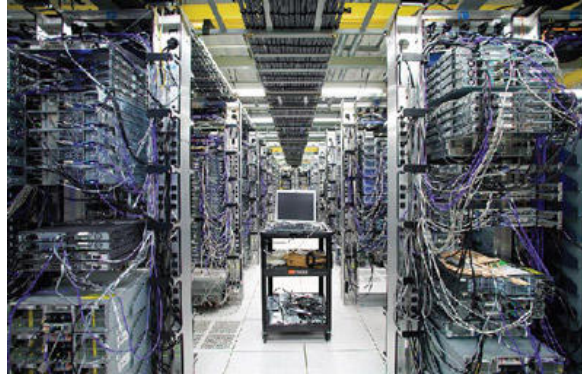
We think of light and fluffy things...

Raw Materials Needed for IT Infrastructure

The Cloud



<https://hydrosystemsco.com/taking-technology-to-new-heights/>



<http://embedindia.blogspot.com/2011/12/cloud-computing-technology.html>

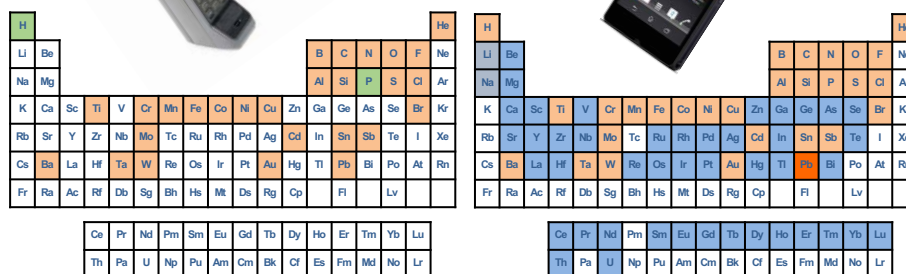
The Cloud is made of *METALS*

Raw Materials — Changing Needs

Technology is growing more complex

Old

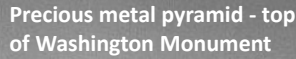
New



~30 elements

~75 elements

Technology is growing more complex



Platinum Group Elements										Other ECEs										He										
1 H Hydrogen 1.01																				2 He Helium 4.00										
3 Li Lithium 6.94	4 Be Beryllium 9.01																	5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16.00	9 F Fluorine 19.00	10 Ne Neon 20.18							
11 Na Sodium 22.99	12 Mg Magnesium 24.31																	13 Al Aluminum 26.98	14 Si Silicon 28.09	15 P Phosphorus 30.97	16 S Sulfur 32.07	17 Cl Chlorine 35.45	18 Ar Argon 39.95							
Rare Earth Elements																				Photovoltaic ECEs										
Battery metals																														
19 K Potassium 39.10	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52.00	25 Mn Manganese 54.94	26 Fe Iron 55.85	27 Co Cobalt 58.93	28 Ni Nickel 58.69	29 Cu Copper 63.55	30 Zn Zinc 65.38	31 Ga Gallium 69.72	32 Ge Germanium 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.90	36 Kr Krypton 83.80													
37 Rb Rubidium 85.47	38 Sr Strontium 87.62	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	42 Mo Molybdenum 95.94	43 Tc Technetium (98)	44 Ru Ruthenium 101.07	45 Rh Rhodium 101.07	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 127.60	53 I Iodine 126.90	54 Xe Xenon 131.29													
55 Cs Cesium 132.91	56 Ba Barium 137.33	57 La Lanthanum 138.91	58 Ce Cerium 140.12	59 Pr Praseodymium 140.91	60 Nd Neodymium 144.24	61 Pm Promethium (145)	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolinium 157.25	65 Tb Terbium 158.93	66 Dy Dysprosium 162.50	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97														
87 Fr Francium (223)	88 Ra Radium (226)	89 Ac Actinium (227)	90 Th Thorium (232)	91 Pa Protactinium (231)	92 U Uranium (238)	93 Np Neptunium (237)	94 Pu Plutonium (244)	95 Am Americium (243)	96 Cm Curium (247)	97 Bk Berkelium (247)	98 Cf Californium (251)	99 Es Einsteinium (252)	100 Fm Fermium (257)	101 Md Mendelevium (258)	102 No Nobelium (259)	103 Lr Lawrencium (262)														



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Raw Materials (Building Materials)

Shanghai 1987

The Atlantic magazine

Shanghai 2013



The explosive growth in China (still ongoing) will be joined by the need to rebuild energy efficient infrastructure in the developed world and to start construction of energy efficient building in the developing world.

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Raw Materials Fun Facts



Ciarán Seoighe
@Ciaran_Seoighe

Friday Fact: How we manage Earth's resources is a Grand Challenge. Global copper production is 22x higher than 100 years ago & China used more cement in the last 3 years than the US in 100 years! Check out potential solutions [@ICRAGcentre @UNESCO sfi.ie/research-news/...](https://www.sfi.ie/research-news/)

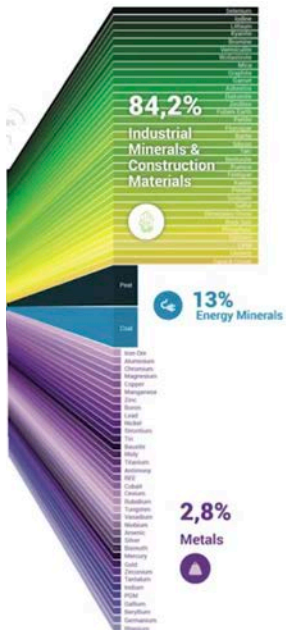
12:03 PM · Jan 29, 2021 · Twitter Web App

4 Retweets 11 Likes

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More Raw Materials Fun Facts



- Metals make up a minority of global commodities by production, volume and value.
- The majority of mineral commodities produced are not exported.
- Large-scale multi-national mining companies are relatively speaking minor players in the global minerals sector.
- The vast majority of materials mined are rarely noticed by society (quarries, sand pits, etc.).

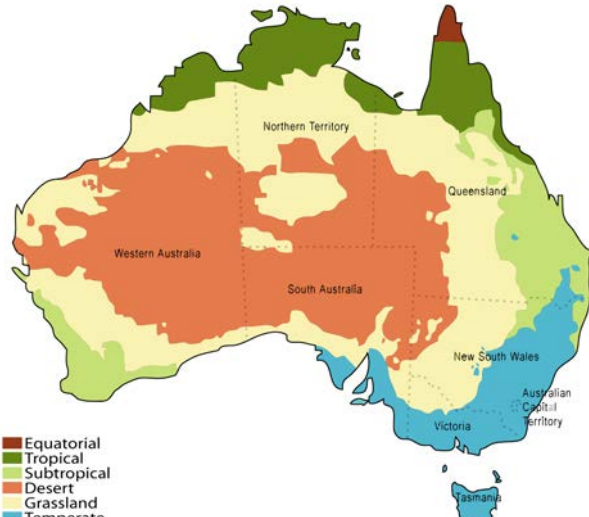
Daniel Franks — Program Leader
Sustainable Minerals Institute, *University of Queensland*
9 Feb. 2021

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Environment

- Really too broad a term.
- But there will be “environmental” jobs in academia, industry and government and a host of research problems that can be funded throughout the Energy Transition.
- Geoscience is foundational along with bioscience for what are now termed environmental studies.



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Climate



- Too many think of climate scientists as only modelers.
- However, the modelers require data - of the present and from past climates - these data come largely from geoscientists.
- The public thinks of “climate change” in terms of the future of the planet — Earth scientists study its past and present and are critical to predicting its future.

Hazards

- Of critical, and growing, importance with climate change as we respond with both mitigation and adaptation.
- Research and jobs from the very geo-technical to statistical (insurance).
- Will be growing requirement for individuals with skills in geohazards in private sector and government.



Biodiversity depends on Geodiversity



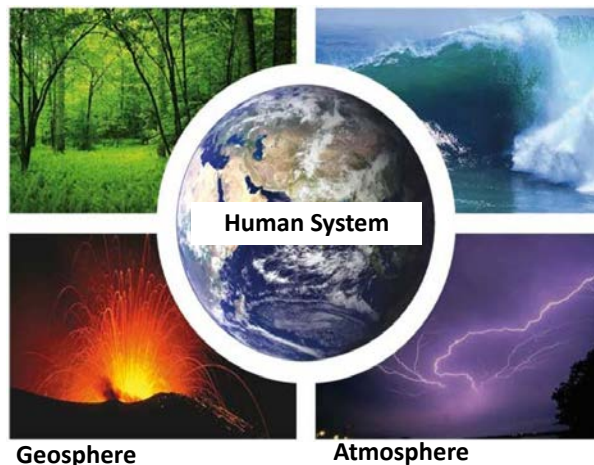
- The biosphere which supports life on Earth extends upwards from the Earth's surface to the Troposphere (19 km) and down to possibly 5 km below the Earth's surface, a total thickness of about 26 km circling the globe.
- The biosphere represents approximately 0.4% of the Earth's diameter (12,742 km) *(It's small!)*
- *Understanding the geodiversity of this thin band around our planet is crucial to preserving biodiversity.*

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Humans Link the Spheres in the Anthropocene

Biosphere

Hydrosphere



Geosphere

Atmosphere

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The Energy Transition

Though fewer will be employed in the fossil fuel sector moving forward we need to preserve their knowledge and skills.

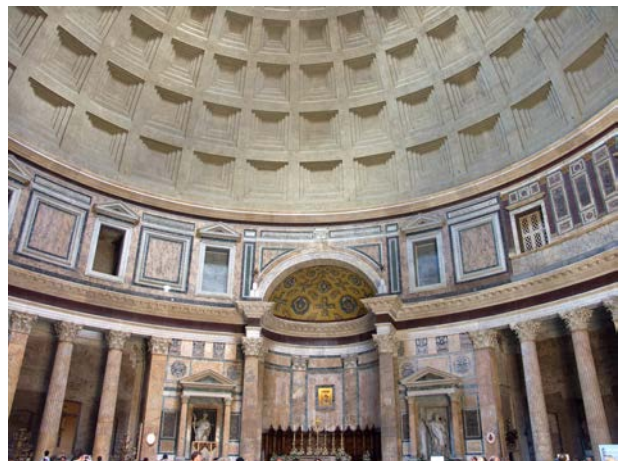


<https://www.dnvgl.com/news/authors-of-energy-transition-outlook-make-its-dataset-freely-available--143475>

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- The ceiling of the Pantheon in Rome is 2000 years old and is the largest unreinforced concrete dome in the world.
- We still do not know exactly how to make this Roman concrete though recent mineralogical and material science research is providing clues.



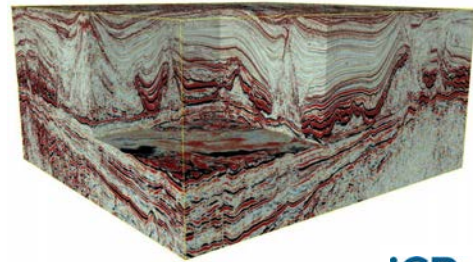
Let's not forget what we know now

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Let's not forget what we know now

- The technology and knowledge in the oil and gas industry is astounding.
- How do we ensure that the knowledge and expertise is not lost and that it is put to use to solve other societal problems including the Climate Emergency?



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An Example from an Earlier Era to to Retain and Retrain



**Nonproliferation and Threat Reduction
Assistance: U.S. Programs in the Former
Soviet Union**

Amy E. Woolf
Specialist in Nuclear Weapons Policy

March 6, 2012



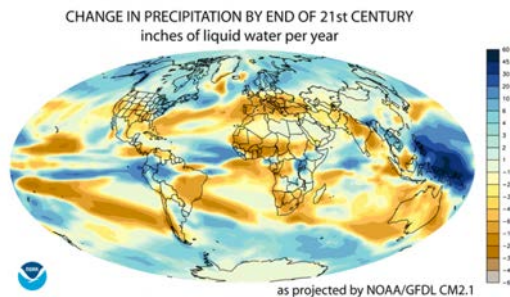
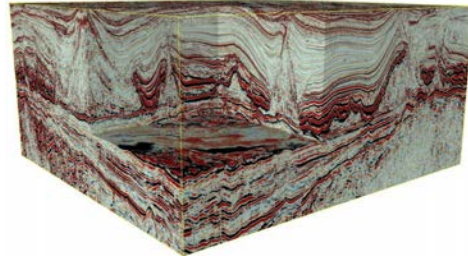
- At the end of the Cold War USSR and USA scientists worked together on nuclear arms reduction and the spread of nuclear know-how.
- Perhaps in the Climate Emergency some governments should work to preserve and utilize the incredible technology and knowledge of the multi-national O&G companies?

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For Example — BIG Data / AI

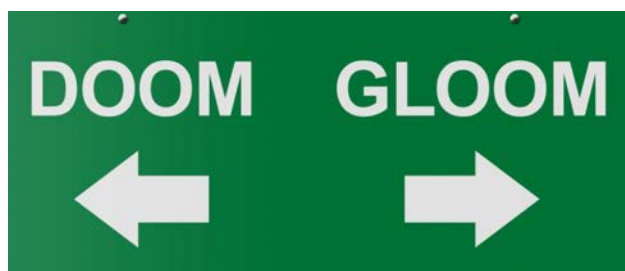
- The BIG data produced and utilized by the O&G industry provides superb data sets and ideas for how to manipulate and approach machine learning.



- Taken together with machine learning in other geoscience areas (climate, hydrology, etc.) there is a rich future for geoscience-data science fusions.

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All is not



You are actually here



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Energy Transition

All other forms of energy technologies require geoscience materials and knowledge.



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The Circular Economy

Geoscience skills needed throughout:

- Discovery & production of materials
- Environmental treatment of all wastes
- Materials stewardship to ensure produced metals/materials stay in use as long as possible



http://podgoricki-klub.me/userfiles/file/1st%20forum/prezentacije/Karen%20Hanghoj_Science%20and%20Innovation%202030_hanghoj.pdf

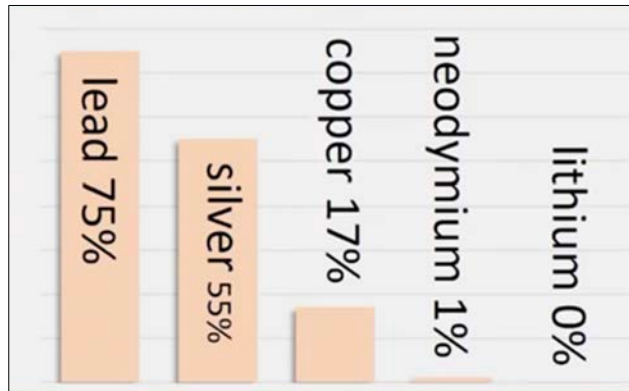
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“Circular economy is based on the principles of

- **designing out waste and pollution,**
- **keeping products and materials in use, and**
- **regenerating natural systems.”**

Ellen MacArthur Foundation



Recycling Input Rates (EU Raw Materials Scoreboard)

Ellen MacArthur Foundation

We have a long way to go...



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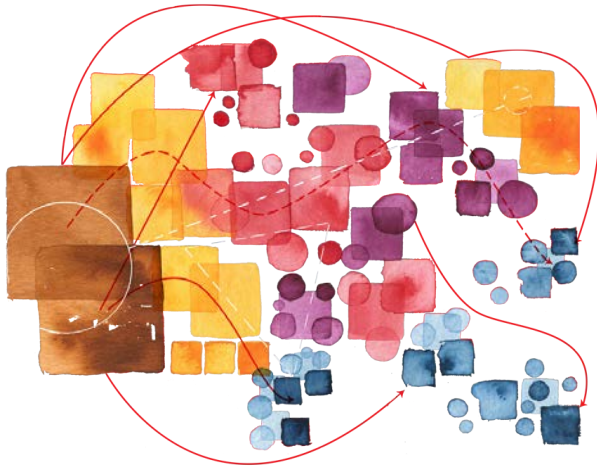


Those with less economic ability often recycle more than those of us with more economic ability - perhaps we need to learn from them?



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Supply Chains in the Circular Economy



<https://kit.exposingtheinvisible.org/en/what/supply-chain.html>

Geoscience forensic examination of materials —

- When produced,
- In manufactured products,
- In wastes from production, manufacturing and post-usage, as well as
- Geospatial analysis of supply chains

is needed if the circular economy is to be secure.

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Geoscience will be **critical** to the Energy Transition and geoscience knowledge is required to ensure that we successfully address the UN Sustainable Development Goals.



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Sometimes a change of view (say from the South)
can help clarify things...



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Sometimes a change of view (say from the South)
can help clarify things...



Australia today relies heavily on
geoscience in terms of national GDP.

Though there will be undoubted change,
with for instance reduction of the
thermal coal industry and a decline in oil
and gas exploration, there will be
incredible OPPORTUNITIES.

https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html



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OPPORTUNITIES

- Booming mineral sector - especially battery metals (Ni, Co, Mn) and IT metals (Cu) but also infrastructure metals and building/development materials (Fe, sand, gravel and stone).
- Growing environmental sectors.
- Everything water.
- Application of geoscience technologies and understanding to supply chain validation and implementation of a circular economy.
- Application of O&G technologies together with spatial machine learning/AI to multiple societal problems.

https://www.nasa.gov/topics/earth/earthday/gall_earth_night.html



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Environmental, Social and Governance Issues UNESCO Lecture Series: Earth Materials for a Sustainable and Thriving Society

iCRAG has organized a lecture series with UNESCO and IUGS with speakers from around the globe — going on until March 9.

<https://bit.ly/UNESCOlectures>



UNESCO Lecture Series

Earth Materials for a Sustainable and Thriving Society
Organised in collaboration with IUGS and iCRAG
PROGRAMME



Minerals and other Earth materials are a key component in the development of a sustainable global society, providing essential raw materials for technologies and economic growth while respecting the natural world. This programme of lectures, designed for a global audience, will provide diverse perspectives on Earth materials and their role in society. Leading natural scientists, social scientists, and educators will look at how Earth materials are critical to a sustainable future and how the minerals sector, adhering to best practices, can contribute to society in a socially and environmentally positive way.



The lectures will be delivered in webinar format by recognized global experts who will frame their presentations in the context of the United Nations Sustainable Development Goals. The Series will boost knowledge of Earth materials and contribute to better informed local, regional, and international discussions. The lectures will be freely accessible and will be archived for later online access.



The Lecture Series is sponsored by UNESCO, the only United Nations organization with a mandate to support research and capacity building in the Earth Sciences. The Series supports the vision of UNESCO's International Geoscience Programme for efficient, safe, sustainable and renewable natural resources exploration and extraction.

- UNESCO is the only United Nations organization with a mandate to support research and capacity building in the Earth Sciences.
- The UNESCO International Geoscience Programme (IGCP) serves as a knowledge hub of UNESCO to facilitate international scientific cooperation in the geosciences.
- The International Union of Geological Sciences (IUGS) encourages international co-operation and participation in the Earth Sciences in relation to human welfare.
- iCRAG, the Science Foundation Ireland Research Centre for Applied Geosciences, is a team of researchers creating solutions for a sustainable society.

The lecture series will commence 26 January 2021.
To register, visit: <https://bit.ly/UNESCOlectures>
For more information, please email: unescolectures@icrag-centre.org

Organising Partners



All sessions will be conducted in English with live captioning in French, Spanish, Portuguese, Arabic, Swahili, and Hindi.

All sessions will include a live public question and answer period with the presenters immediately following the lecture presentations.



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